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AGRICULTURAL MEMORANDUM NO 970

A Computerised Analysis of Air Trajectories over the Sea

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INTRODUCTION

Agricultural Memorandum No 969 described a method by which air trajectories over the sea could be estimated from simple meteorological data using the following three algorithms:-

(1) The difference between the true direction of movement of the plume (θ) and the surface wind direction (θ_{10}).

$$\theta - \theta_{10} = \frac{21.5}{1 + e^{(0.03 + (-0.475 + \ln u_{10})(T_{10} - T_S))}}$$

where u_{10} = Wind speed measured at 10m ($m\ sec^{-1}$)

T_{10} = air temperature measured at 10m (^{o}C)

T_S = Sea Temperature (^{o}C)

(2) The distance travelled in 1 hour by the plume (d)

$$d = (-2.82 + 5.54\, u_{10})\, e^{(0.10\, e^{-0.11 u_{10}})(T_{10} - T_S)}$$

FH2B

(3) The theoretical height of the top of the mixing layer at the time of observation (h)

$$h = 28.2\, u_{10}^{1.35} (T_{10} - T_S)^{(-0.5 + 0.006\, u_{10})}$$

These algorithms have been incorporated into a computer program which can be run on the Meteorological Office computer system (COSMOS). This memorandum gives an example of an air trajectory analysis using this program.

AIR TRAJECTORY ANALYSIS

PERIOD OF ANALYSIS

The 7th and 10th March 1981 were chosen as two suitable occasions to test the new computer program. Air trajectories for both of these days had already been estimated in connection with Foot-and-Mouth disease outbreaks in Brittany, France and subsequently in Jersey and the Isle of Wight. (Donaldson and others 1982); in their analysis they assumed that the whole plume travelled from the direction of and with the speed of the surface wind. The new analysis assumes that the movement of the plume can be better represented by taking into consideration the wind speed and direction at all heights in the mixed layer.

Analysis

Hourly meteorological surface charts, for the 7th and 10th March, were obtained from the Meteorological Office archives section. The movements of parcels of air, starting at 6 hourly intervals, which had passed over the affected animals in Brittany were then estimated.

Figure 1 and Figure 2 give two examples of the air trajectories. Tables 1 and 2 give the meteorological input data and the calculated values of d, $\theta - \theta_{10}$ and h for the same air trajectories. Figures 3 and 4 show the paths of all the trajectories for the 7th and 10th March respectively and Tables 3 and 4 present additional information about each of the trajectories.

COMMENTS ON THE TRAJECTORY ANALYSIS

1. The results broadly confirm the findings of Donaldson and others (1982) who concluded that air which would have passed over diseased animals in Brittany would have passed over livestock in Jersey and the Isle of Wight. However, in the new analysis the direction of travel of the centre of the plume is continually veered by $\sim 13^{\circ}$ from the surface wind direction.

2. Donaldson and others (1982), using a method described by Gloster and others (1982), concluded that airborne virus particles would have, on occasions, been confined to a height of a few hundred metres above the sea. Although this analysis confirms that conclusion it quantifies the average maximum height for virus dispersion as 500-700 metres.

REFERENCES

DONALDSON, A.I., GLOSTER, J., HARVEY, L.D.J and DEANS, D.H. (1982)
Veterinary Record 110, 53-57.

GLOSTER, J., SELLERS, R.F. and DONALDSON, A.I. (1982)
Veterinary Record 110, 47-52.

Any comments or suggestions on this paper should be referred to the author, Meteorological Office, London Road, Bracknell, Berkshire.

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Table 1: Air Trajectory, start 6Z 7th March 1981

Observation Time[1] (hrs)	Air Temp[2] (°C)	Sea Temp[3] (°C)	Wind Speed[4] (kts)	Wind Direction[4] (°)	d (km)	$\theta - \theta_{10}$ (°)	h (m)
6	12	9	15	190	42	14	219
7	11	9	15	190	40	13	256
8	10	9	15	190	39	12	323
9	11	9	20	180	57	13	421
10	11	9	20	190	57	13	421
11	11	9	20	190	57	13	421
12	11	9	30	200	84	12	749

Table 2: Air Trajectory, start 12Z 10th March 1981

12	15	9	15	180	49	17	165
13	13	9	15	180	44	15	195
14	11	9	15	180	40	13	256
15	12	9	5	200	11	16	42
16	13	9	15	200	44	15	195
17	12	9	15	210	42	14	219
18	12	9	20	210	59	13	363
19	9	9	15	190	37	11	535
20	9	9	15	200	37	11	535
21	9	9	10	230	26	11	343
22	10	9	15	250	39	12	323

1. GMT.
2. Air temperature measured at 10 m.
3. Surface sea temperature.
4. Wind speed and direction measured at 10 m.

Table 3: Air Trajectories 7th March 1981

Trajectory start time[1] (hrs)	Journey Time to English Coast (hrs)		Average $(\theta - \theta_{10})$ (^{o})	Maximum mixing height (m)
0	7	(9)*	12	535
6	5	(7)	13	749
12	5	(7)	13	545
18	5	(8)	12	678
24	5	(7)	13	678

Table 4: Air Trajectories 10th March 1981

0	7	(10)	12	528
6	6	(9)	13	545
12	6	(9)	13	535
18	5	(8)	14	749

* The values quoted in ( ) are the time that a plume travelling at the speed of the surface wind alone would have taken to reach the English coast.

1. GMT.

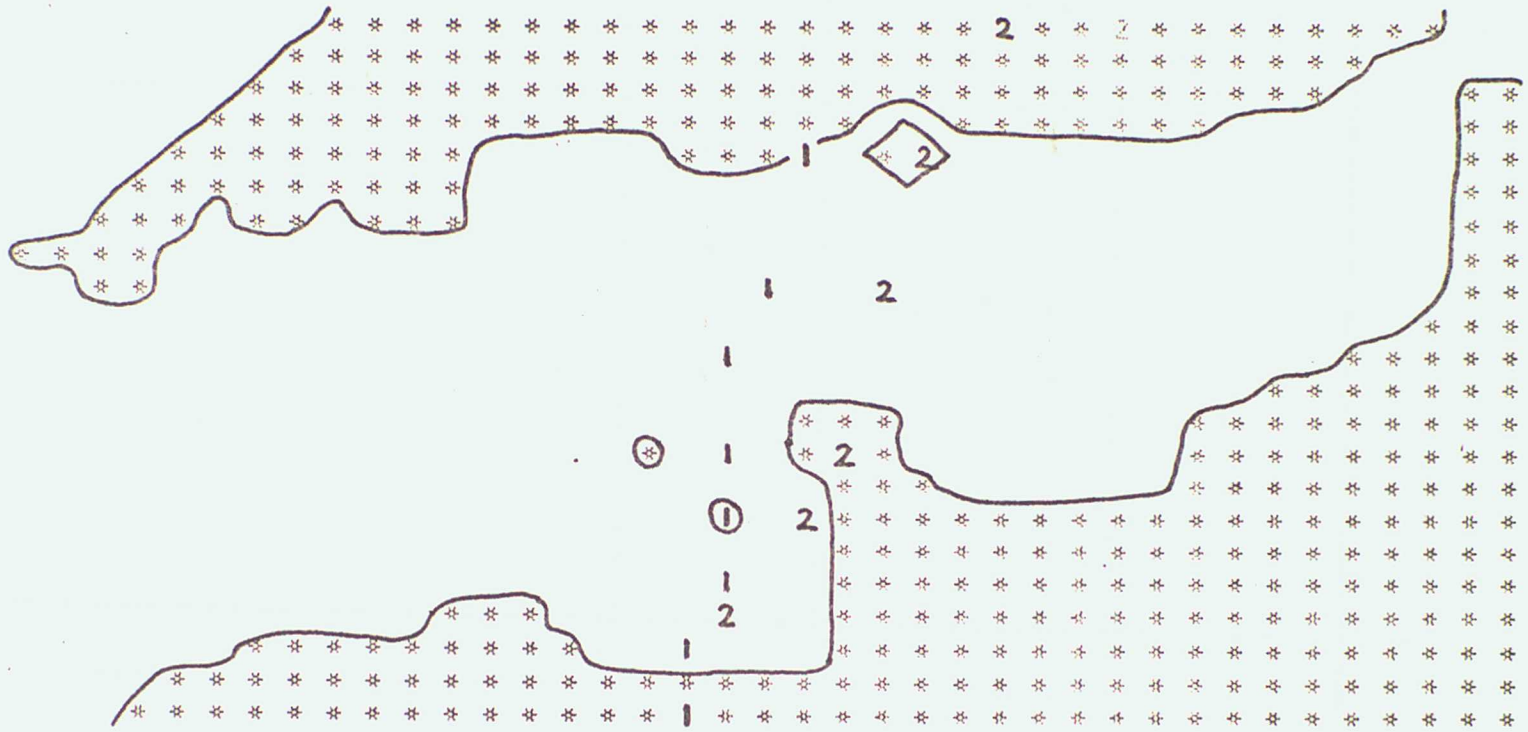

FIGURE 1. Result of an air trajectory analysis

Start time 6 G.M.T. on 7/3/81

1. Centre of the tract of the pluma based on surface movement only.
2. Centre of the tract of the plume allowing for the change of windspeed and direction with height.

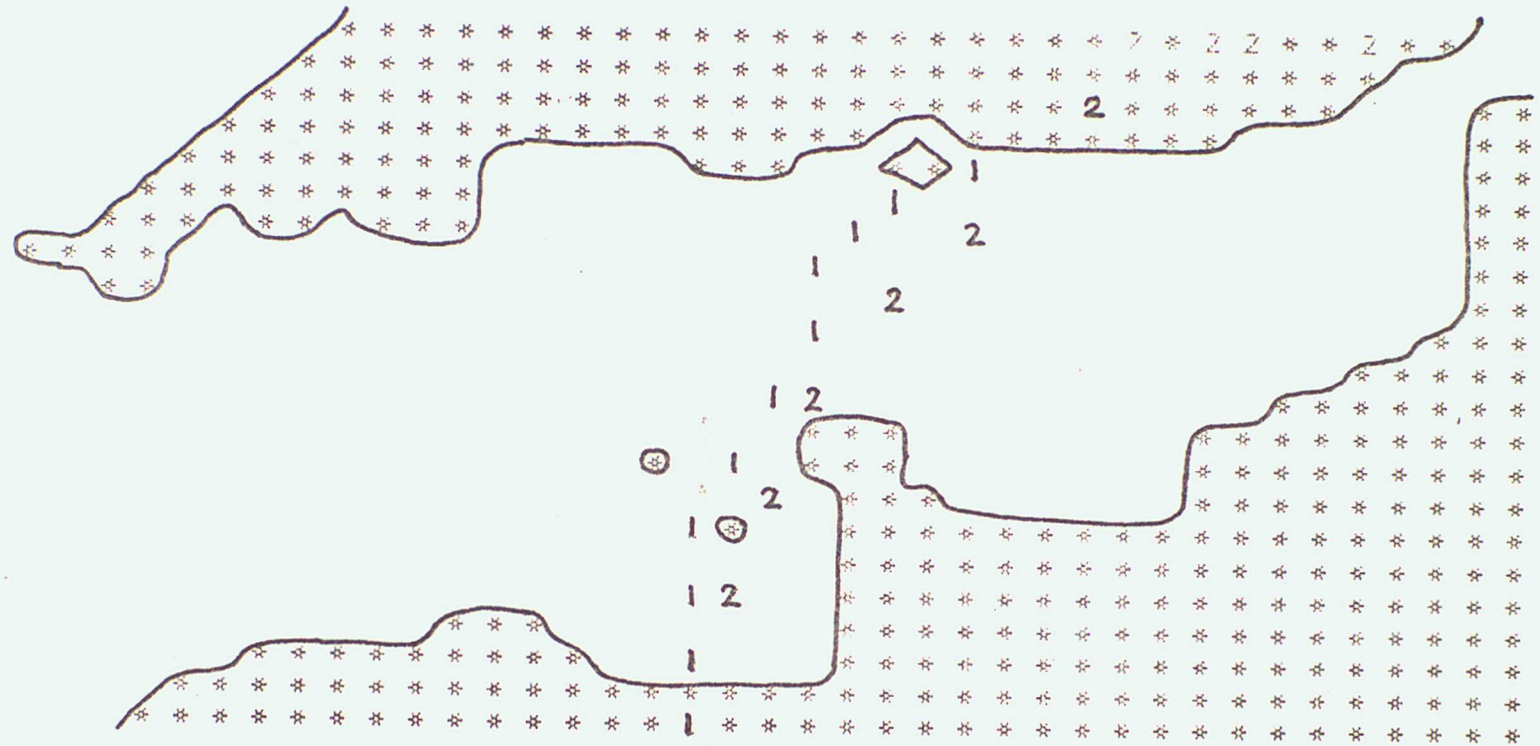

FIGURE 2. Result of an air trajectory analysis

start time 12 G.M.T. on 10/3/81

1 and 2 as defined in FIGURE 1.

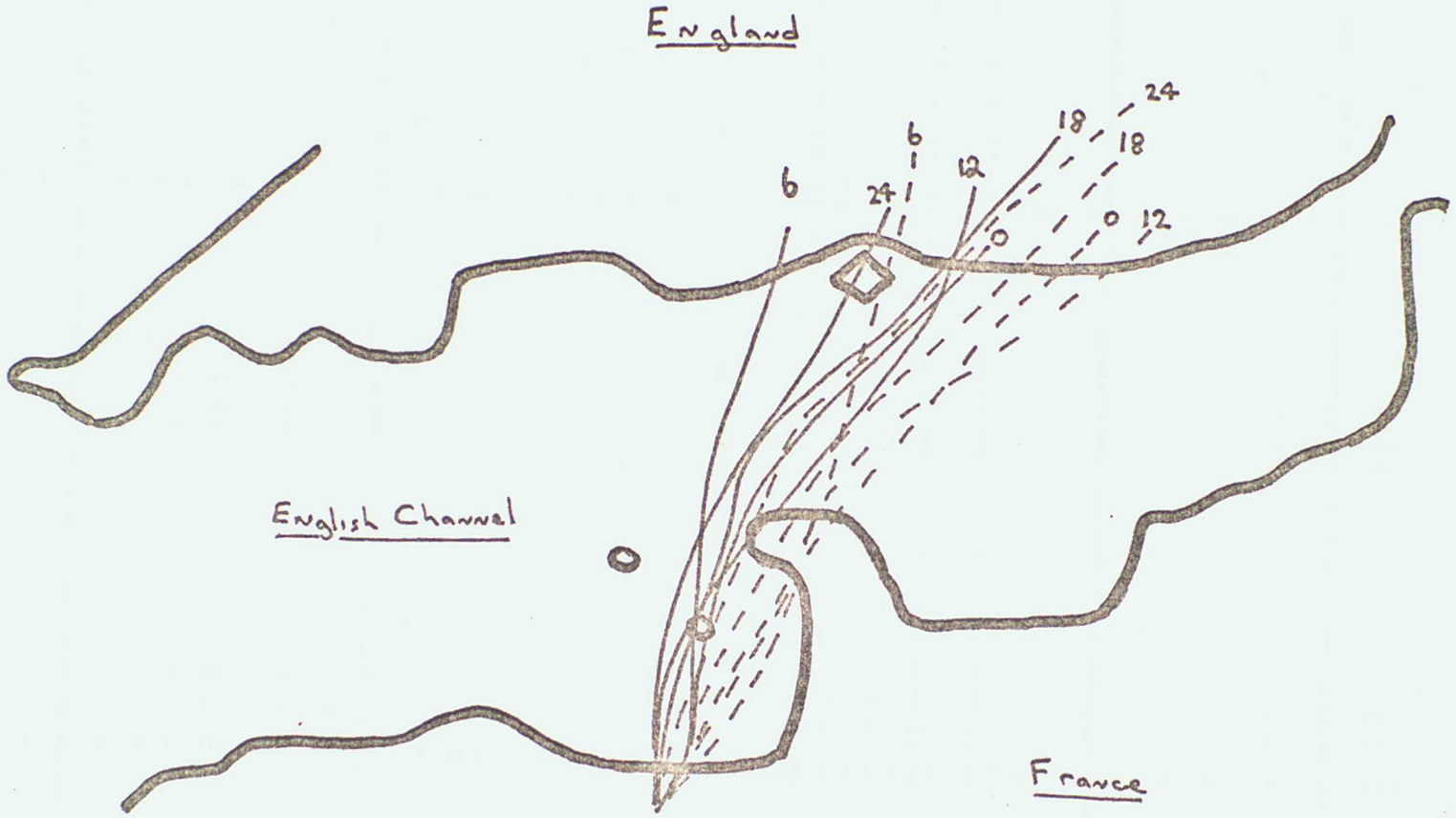

FIGURE 3 Summary of air trajectories for 7/3/81

—— as for 1 in FIGURE 1

– – – as for 2 in FIGURE 1

6 start time of trajectory.

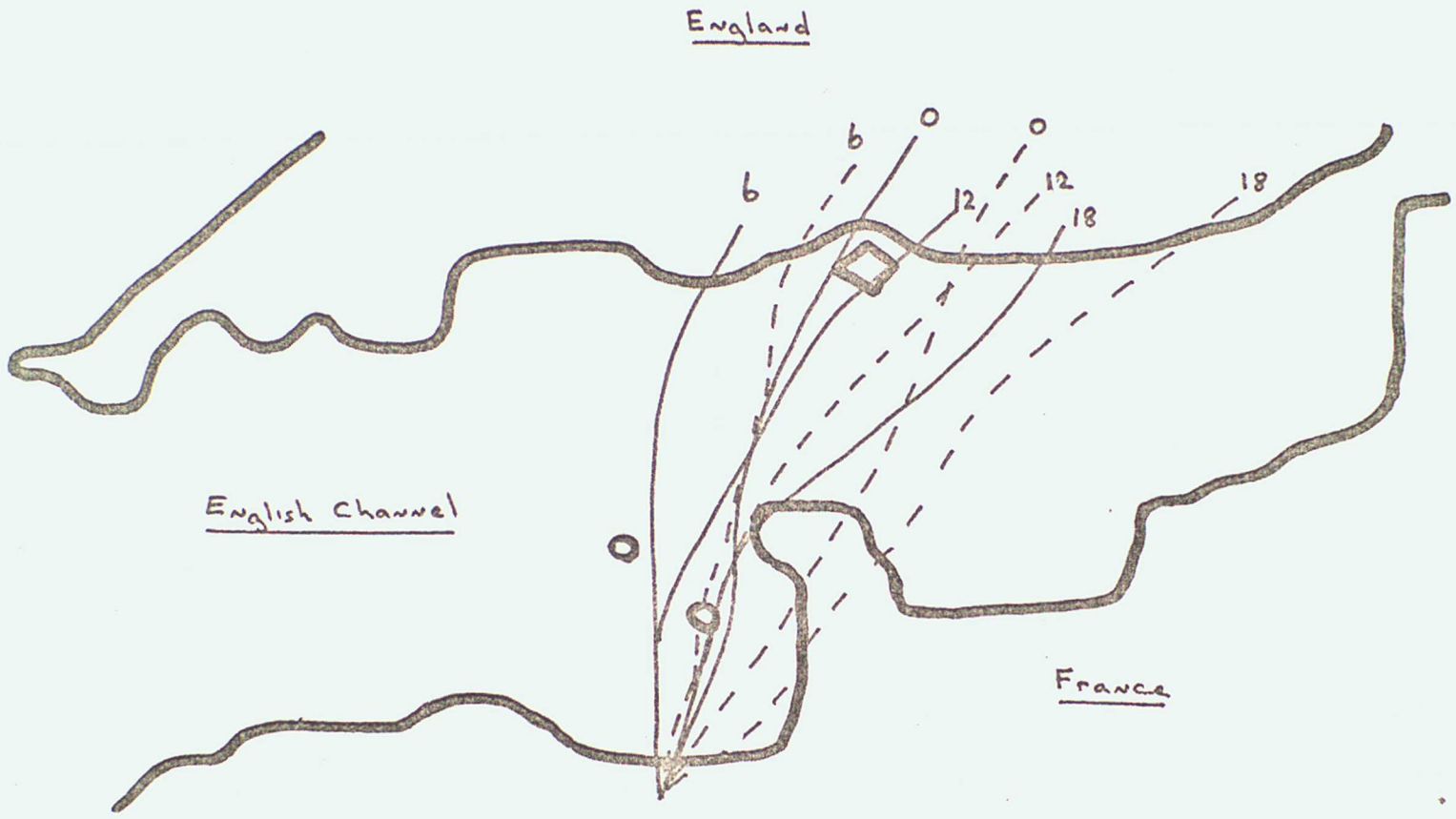

FIGURE 4 Summary of air trajectories for 10/3/81

—— as for 1 in FIGURE 1

- - - as for 2 in FIGURE 1

b Start time of trajectory.